CLAIMS

What is claimed is:

1. A combination voltage converter circuit for performing multiple operating functions, the combination circuit comprising:

an RF coil (L1') having a first end (72'), a second end (85), and a tap point (85');

a diode (D1) connected between the first end (72') of the RF coil (L1') and an output node (75');

a first capacitor (C1) connected between the output node (75') and ground potential (87);

a first transistor switch (M1') connected between the second end (85) of the coil (L1') and a primary power source (V_S);

a second transistor switch (M2) connected between the tap point (85) and the primary power source (V_S);

a second diode (D2) connected between the tap point (85) and ground potential (87);

a data amplifier (U1) having an input and an output;

a third diode (D3) connected between the first end (72') of the RF coil (L1') and the input of the data amplifier (U1);

a third transistor switch (M3) connected between the input of the data amplifier (U1) and ground potential (87);

a tuning capacitor (C3') having a first side connected to the first end (72') of the RF coil (L1') and a second side connected to the tap point (85') through a fourth transistor switch (M4); and

a fifth transistor switch (M5) connected between the tap point (85') and ground potential (87).

2. The combination circuit of Claim 1, wherein the combination circuit is configured such that,

when transistor switches M2, M4 and M5 are turned OFF, and transistor switch M1' is turned ON, and transistor switch M3 is modulated with a pulse-width modulated (PWM) signal, a voltage is generated at the output node (75') that is stepped up from the voltage of the primary power source (V_S); and

when transistor switches M1', M3, M4 and M5 are turned OFF, and transistor switch M2 is modulated with a PWM signal, a voltage is generated at the output node (75') that is stepped down from V_S; and

when transistor switches M1', M2 and M3 are turned OFF, and transistor switches M4 and M5 are turned ON, the combination circuit operates in an energy receive mode wherein RF energy received through the RF coil (L1') is rectified and stored in capacitor C1, and also operates in a data receive mode wherein data modulating the received RF energy is demodulated through diode D3 and recoverable as data at the output of amplifier U1; and

when transistor switches M1', M4 and M5 are turned ON, transistor switch M2 is turned OFF, and transistor switch M3 is modulated with data, the combination circuit operates in a data transmit mode wherein the data modulating transistor switch M3 is transmitted from the RF coil (L1').

3. The combination circuit of Claim 2, wherein the combination circuit is configured for use in an implantable medical device.

4. The combination circuit of Claim 3, wherein the tap point (85') on the RF coil (L1') divides the coil into N1 turns between the tap point and the first end (72') of the coil, and N2 turns between the tap point and the second end (85) of the coil, and wherein the inductance value of the RF coil is between 1 μH and 1000 μH.

5. The combination circuit of Claim 3, wherein the number of turns N1 is between about 1 and 1000 turns and the number of turns N2 is between about 1 and 1000 turns.

6. A combination voltage converter circuit for performing multiple operating functions, the combination circuit comprising:

a coil designated as L1' having a first end (72'), a second end (85), and a tap point (85'), wherein the tap point (85') on the RF coil (L1') divides the coil into N1 turns between the tap point and the first end (72') of the coil (L1'), and N2 turns between the tap point and the second end (85) of the coil; and

circuit means, including switches, for implementing operating modes and switching between operating modes of the combination circuit,

wherein the operating modes include (i) power receive inductively through the coil (L1'), (ii) voltage step up conversion using the coil (L1') and (iii) voltage step down conversion using the coil (L1'); and

wherein the coil is coupled to the circuit means.

7. The combination circuit of Claim 6,

wherein the number of turns N1 is between about 1 and 1000 turns and the number of turns N2 is between about 1 and 1000 turns; and

wherein the inductance value of the coil (L1') is between about 1 μH and 1000 μH.

8. The combination circuit of Claim 7, wherein, in the voltage step down conversion operating mode, only the N1 part of the coil L1' is used.

9. The combination circuit of Claim 6,

wherein the circuit means and the coil are configured to receive data or commands via the coil concurrent to receiving power inductively; and

wherein the operating modes include four modes: (i) power receive inductively through the coil and, concurrently, data receive through the coil (ii) voltage step up conversion using the coil (iii) voltage step down conversion using the coil and (iv) data transmit through the coil.

10. The combination circuit of Claim 9,

wherein the switching means comprises first (M1'), second (M2), third (M3), fourth (M4) and fifth (M5) transistor switches, which switches are selectably turned on, turned off, or modulated in various switch combinations to configure the combination circuit to at least one of the four operating modes; and

wherein the selection of the operating modes is implemented through a time multiplexing scheme.

11. The combination circuit of Claim 10, wherein the circuit means includes a pulsewidth modulation (PWM) circuit for controlling one of the transistor switches, which PWM circuit is used for voltage step up conversion or voltage step down conversion.

12. The combination circuit of Claim 10, wherein the circuit means includes an ON/OFF modulation (OOM) low power circuit for controlling one of the transistor switches, which OOM circuit is used for voltage step up conversion or voltage step down conversion.

13. The combination circuit of Claim 10,

wherein the number of turns N1 is between about 1 and 1000 turns and the number of turns N2 is between about 1 and 1000 turns; and

wherein the inductance value of the coil (L1') is between about 1 μH and 1000 μH.

14. The combination circuit of Claim 13, wherein, in the voltage step down conversion operating mode, only the N1 part of the coil L1' is used.

15. The combination circuit of Claim 13, wherein, in the energy receive and data receive operating modes, only the N1 part of the coil L1' is used.

16. A method for using a single, combination voltage converter circuit to perform multiple operating functions in an implantable medical device, the method comprising:

(a) providing an electronic circuitry, including a coil, which electronic circuitry is incorporated in the implantable device, wherein the electronic circuitry includes a plurality of switches;

(b) selecting one of the operating modes of the combination circuit, wherein the possible operating modes of the combination circuit include: (i) power receive and, concurrently, data receive using the coil, (ii) data transmit using the coil and (iii) voltage step up conversion using the coil, and (iv) voltage step down conversion using the coil; and

(c) repeating the step (b) above as many times as necessary to provide a desired sequence of operating modes, and thereby implementing each operating mode in a time-multiplexed scheme.

17. The method of Claim 16,

wherein the step (b) selecting one of the operating modes of the combination circuit is accomplished by using transistor switches, which transistor switches comprise a first (M1'), second (M2), third (M3), fourth (M4) and fifth (M5) transistor switches; and

wherein the switches are turned on, turned off, or modulated in various switch combinations to configure the combination circuit to at least one of the four operating modes.

18. The method of Claim 17,

wherein the step (b) selecting the operating mode for (iii) the step up voltage conversion or for (iv) the step down voltage conversion is accomplished by applying modulation to one of the transistors; and

wherein modulation is produced at the modulated transistor from a pulse-width modulated (PWM) circuit or an ON-Off modulation (OOM) low power modulation circuit.

19. The method of Claim 17,

wherein the step (b) selecting the operating mode for (i) of the combination circuit for the power receive and data receive mode is accomplished by receiving alternating RF energy signals through the RF coil (L1'), rectifying the energy signals and storing the energy in capacitor C1 and, concurrently, data modulating the received RF energy signals, demodulating the signals through a diode D3 and recovering data at the output of amplifier U1; and

wherein the transistor switches M1', M2 and M3 are turned OFF and transistor switches M4 and M5 are turned ON.

20. The method of Claim 17, wherein the step (b) selecting the operating mode of the combination circuit for (iv) the data transmit mode is accomplished by turning ON the transistor switches M1', M4 and M5, turning OFF transistor switch M2, and modulating the transistor switch M3 to modulate data which is transmitted from the coil (L1').